PRESS EQUIPMENT TOOL DESIGN FOR HUMAN FACTORS

The purpose of this paper is to determine whether hand tools currently being used in press equipment operations can be improved upon from a Human Factors Engineering perspective. Design improvements would be in order to encourage and foster greater operator safety and reduce the likelihood of the development of overuse disorders (OD's), otherwise known as cumulative trauma disorders (CTD's). Although certain observations may be made, identification of and recommendations for every ergonomic consideration regarding current press equipment is beyond the scope of this paper.

Forward

In modern materials manufacturing, metals are produced by two primary methods. Initially, all metals are cast. Molten metals are cast into ingots, which are further processed into stock (billets, bar, wire, etc.) by a variety of methods. The stock (or raw) material is then transformed in near-finished product by either casting or forging.

Casting: Where the original mill-produced metal is melted and reformed, or cast, into a mold. Casting is a generic term referring to a process where a fluid material (usually a molten alloy) is made to flow into a shaped mold cavity where it solidifies; this method is used to produce complex component shapes and properties difficult to achieve otherwise.

Forging: Where the original mill-produced metal is formed into shape mechanically using presses or forging machinery of various types. It is also described as the mechanical forming of a metal by heating and hammering. In press operations, cold forming is used, which is also a type of forging process. Forging produces the strongest materials of all secondary metal processing operations, and is mandatory wherever a high strength, high durability product is required.

This paper will focus on the manufacture of the forged product, particularly the hand tools used in the cold forming of small (<1" in diameter) fasteners (nuts, bolts, rivets, etc.)

The most common hand tool used in small press operations is the tweezer. Tweezers are used to pick up, hold, and align parts into a press machine. This operation is performed hundreds of times per day by experienced personnel.

Image 1

Image 1: Large industrial tweezer.

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Human Factors Problem

The hypothesis is that is that the use of the hand tools provided to workers in press operations would be more conducive to continuous long-term utilization if the tools are ergonomically designed.

It is believed that the tweezers currently provided to machine operators can be better designed to reduce operator fatigue. The objective is that the use of the tools would be more conducive to continuous long-term utilization. Otherwise, the tendency is for employees to revert to inserting their hands into the machinery (in order to meet production goals and achieve the expected parts-per-hour production rate). It is easier to replace a damaged tool than a finger; but if the tool causes cramps or pain, the tool may not be used. Safety is compromised anytime a body part is inserted into a machine.

Overview of Equipment Currently in Use

Much of the press equipment currently in use was designed in the 1950's and 1960's, with obviously little consideration for ergonomic factors. One of the first things that is readily apparent is the lack of leg space for the operator. For the most part, operators are forced to sit (or stand) very close to the machine. In doing so, when sitting, the operator must fold his or her legs back and under the stool that is normally provided. Additionally, some stools have no back support of any type. This can lead to increased loading of the spine, resulting in lower back pain and operator discomfort. (Kroemer, 2001)

Existing Equipment and Safety

Dual hand switches probably were incorporated into the designs of press equipment from inception, due to the fact that potentially thousands of pounds of pressure generated by the machinery can easily sever a finger. A properly operating press machine will not cycle unless both hand switches are activated simultaneously. Also commonly present are clear plastic eyeguards, although it has not been established whether these were part of the original design or were added later.

Image 2

Over the years several additional types of safety equipment have been added to many presses. These include infrared or optical sensors, which will not let the machine cycle when the beam is interrupted (such as by a hand or tool). These types of sensor arrays act as a supplemental safety feature to the dual hand switches.

Image 2 shows one type of a modern, current production press with integrated safety equipment. The large optical sensor array and dual hand switches are clearly visible. An emergency off button is also evident. This design does allow the operator to position him/her self close to the unit with ample legroom. However, there appears to be no eyeguards installed on this unit, and the optical sensors can be defeated by inserting hands from either side of the machine (beyond the range of the sensors).

This next image shows an older press currently being used almost daily. The optical sensors are installed, and a plastic guard surrounds the working area. This prevents operators from reaching in from the sides, and protects the eyes in case something is ejected while in use. The dual hand switches are also evident, and an emergency off button as well. There is a lamp on the right side to provide illumination of the work area while in use. Other ergonomic observations: There is minimal legroom at the front of the machine, and a chair (stool) is provided. While offering back some lower back support, the backrest itself is not padded. Note the tweezers on the front working surface of the machine.

Image 3

Current Process

The current process is to have the operator positioned in front of the equipment. The item to be pressed is picked up using one of a variety of large industrial tweezers. With the tweezers, the item is then inserted into the machine. The operator must align the object prior to cycling the press, and the tweezer is used to do this as well.

In interviews with press equipment operators, most experienced some discomfort in their hands after a full day of using the tweezers. This may eventually result in an overuse disorder (OD), similar to Carpal Tunnel Syndrome. To date, however, no evidence was found where an operator has submitted a complaint regarding this matter.

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Many chairs (or stools) provided to the operators have back supports, but most are not padded. Rudimentary footrests are provided to the operators as needed. The lighting is marginal, but does exist on each machine. The noise level in the factory is high but tolerable with proper hearing protection, which is provided. Eye protection is mandatory in all production areas. Some operators wear latex gloves to protect hands from contact with metals and lubricants. The air temperature of the working area is controlled and moderate.

Most if not all of the tweezers being used have been modified to some extent. This is accomplished by heating the tips of the tweezer until they are near molten, whereupon the tips are bent in a vice or mandrel. This changes the shape of the tip of the tweezer to facilitate handling of a part, but does little to alter the use to the operator. The operator still must squeeze the tweezer in order to pick up each part for insertion into the press.

Image 4

As shown in the image above, each tweezer tip has been modified to suit a particular application. The tool on the left has square, padded tips and a spring has been installed to keep them open.

An analysis of the spring tension for available tweezers was performed, and all were relatively easy to close. As an object is picked up in the jaws of the tweezer, very little effort is required to hold the object (approximately 3 – 12 in/lbs). Thus the spring tension itself and the effort required to hold an object is not expected to be a major factor in contributing to possible overuse disorders.

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Area Needing Improvement

Although several areas can be easily identified that necessitate HFE intervention, it is the focus of this paper to address possible improvements to the hand tools used by the press operators. In this regard, it is the tweezers that require improvement in order to reduce or eliminate the fatigue experienced by operators. This will also serve to eliminate possible overuse disorders, and is expected to improve safety through increased operator utilization.

HFE Intervention

As described on page 376 of the text (Kroemer, 2001), the position of the operator's hands while using the tweezers is of primary concern. The bent wrist as shown in Figure 8-30 is what commonly occurs when using the tools. A better approach would be to provide tweezers with an angled handle that would allow a more comfortable hand position for the operator.

In conclusion, the Human Factors Engineering Intervention for this issue - to reduce press equipment operator fatigue and the opportunity for the development of overuse disorders – it is suggested that the design of the tweezers be re-engineered to provide:

1) A cushioned, angled handle with a large grip surface for the hand. These may have to be custom made, as several Internet searches performed for the purposes of this paper failed to produce any angle-handled tweezers available through commercial sources.

2) A mechanism for adjusting the spring tension of each tweezer, based upon operator preference and specific application.

3) Alternate types of tweezers that could be used based upon operator preference and specific application. Some examples include:

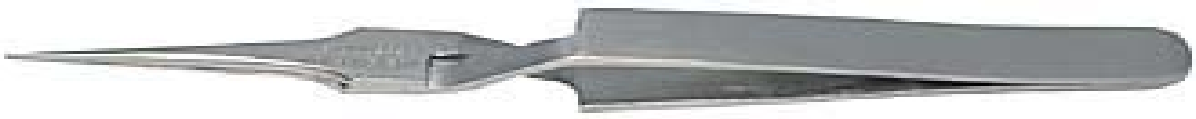

Image 5 - Self – closing tweezer

Image 6 - Locking tweezer

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It is anticipated that operators would be more likely to use the "re-engineered" tweezers without experiencing fatigue, thus resulting in increased safety and a reduction in the possibility of developing an injury or overuse disorder.

Other recommendations, for production efficiency and continuous improvement efforts:

Develop an automatic feed mechanism in order to insert product into the press equipment prior to each cycle. This would completely eliminate the safety concerns of operators inserting hands and arms into the press working area, and greatly reduce the necessity for using tweezers in production press operations. It is the observation of this author that the entire current process is time consuming, labor intensive and not conducive to high levels of production efficiency.

Annotated References

Kroemer, K. H. E. (2001). Ergonomics: how to design for ease and efficiency (2nd ed.). Upper Saddle River, New Jersey, USA: Prentice-Hall, Inc.

General References

American Hand Therapy Foundation Web, http://www.ahtf.org/

The Ohio State University Biodynamics Laboratory
http://osuergo.eng.ohio-state.edu/tooleval.html

Image References

Images courtesy of Daniel C. Sessoms, obtained through digital photography of an industrial workplace and various public-domain sources.